

1      CLAIMS

2      What is claimed is:

3      1. An apparatus for sending a heartbeat signal in cluster

4      computing system, the apparatus comprising:

5            a first host group; and

6            a first storage system associated with the first host

7      group, the first host group configured to selectively send a

8      heartbeat signal to a second host group by use of a network

9      coupled between the first host group and the second host group

10     or by use of a remote link coupled between the first storage

11     system and a second storage system associated with the second

12     host group.

14     2. A method of sending a heartbeat signal in a cluster

15     computing system, the method comprising:

16            generating a heartbeat signal from a first host group;

17            selectively sending the heartbeat signal from the first

18      host group to a second host group by use of a network coupled

19      between the first host group and the second host group or by use

20      of a remote link coupled between a first storage system

21      associated with the first host group and a second storage system

22      associated with the second host group.

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1   3. An electronically-readable medium storing a program for  
2   permitting a computer to perform method of sending a heartbeat  
3   signal in a cluster computing system, the method comprising:  
4       generating a heartbeat signal from a first host group;  
5       selectively sending the heartbeat signal from the first  
6   host group to a second host group by use of a network coupled  
7   between the first host group and the second host group or by use  
8   of a remote link coupled between a first storage system  
9   associated with the first host group and a second storage system  
10   associated with the second host group.

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12   4. A program code embedded on a carrier wave for causing a  
13   computer to perform a method of sending a heartbeat signal in a  
14   cluster computing system, the method comprising:

15       generating a heartbeat signal from a first host group;  
16       selectively sending the heartbeat signal from the first  
17   host group to a second host group by use of a network coupled  
18   between the first host group and the second host group or by use  
19   of a remote link coupled between a first storage system  
20   associated with the first host group and a second storage system  
21   associated with the second host group.

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23   5. An apparatus for receiving a heartbeat signal in cluster  
24   computing system, the apparatus comprising:

1       a remote host group; and  
2       a remote storage system associated with the remote host  
3       group, the remote host group configured to selectively receive a  
4       heartbeat signal from a network coupled with the remote host  
5       group or by use of a remote link coupled to the remote storage  
6       system.

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8       6. A method of receiving a heartbeat signal in a cluster  
9       computing system, the method comprising:

10       selectively receiving a heartbeat signal in a remote host  
11       group by use of a network with the remote host group or by use  
12       of a remote link coupled with a storage system associated with  
13       the remote host group.

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15       7. An electronically-readable medium storing a program for  
16       permitting a computer to perform a method of receiving a  
17       heartbeat signal in a cluster computing system, the method  
18       comprising:

19       selectively receiving a heartbeat signal in a remote host  
20       group by use of a network with the remote host group or by use  
21       of a remote link coupled with a storage system associated with  
22       the remote host group.

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1    8. A program code embedded on a carrier wave for causing a  
2    computer to perform a method of receiving a heartbeat signal in  
3    a cluster computing system, the method comprising:

4            selectively receiving a heartbeat signal in a remote host  
5    group by use of a network with the remote host group or by use  
6    of a remote link coupled with a storage system associated with  
7    the remote host group.

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9    9. A cluster computing system, comprising:

10          a production host group;  
11          a standby host group coupled to the production host group  
12    by a network; and  
13          a remote mirror coupled between the production host group  
14    and the standby host group;  
15          the production host group configured to selectively send a  
16    heartbeat signal to the standby host group by use of at least  
17    one of the network and the remote mirror.

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19    10. A method of checking for failure in a cluster computing  
20    system, the method comprising:

21          generating a heartbeat signal from a first host group;  
22          selectively sending the heartbeat signal from the first  
23    host group to a second to host group by use of a network coupled

1 between the host groups or a remote mirror coupled between the  
2 host groups.

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4 11. A cluster computing system, comprising:

5 a production host group;

6 a standby host group coupled to the production host group

7 by a network; and

8 a remote mirror coupled between the production host group

9 and the standby host group, the remote mirror including a

10 production site heartbeat storage volume (heartbeat PVOL) and a  
11 standby site heartbeat storage volume (heartbeat SVOL) coupled  
12 by a remote link to the heartbeat PVOL;

13 the production host group configured to selectively send a

14 heartbeat signal to the standby host group by use of at least

15 one of the network and the remote link.

17 12. The cluster computing system of claim 11 wherein the

18 production host group comprises a first heartbeat check module

19 configured to generate the heartbeat signal.

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21 13. The cluster computing system of claim 11 wherein the

22 standby host group comprises a second heartbeat check module

23 configured to receive the heartbeat signal.

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1 14. The cluster computing system of claim 11 wherein the  
2 standby host group manages operations of the cluster computing  
3 system if an invalid heartbeat signal is received by the standby  
4 host group from the production host group.

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6 15. The cluster computing system of claim 11 wherein the  
7 heartbeat message comprises: a serial number assigned to the  
8 heartbeat message, a time indicator indicating a time of the  
9 generation of the heartbeat message, and an identifier  
10 identifying a sender of the heartbeat message.

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12 16. The cluster computing system of claim 11 further  
13 comprising:

14 a second remote mirror coupled between the production host  
15 group and the standby host group, the second remote mirror  
16 including a second remote link for transmitting a heartbeat  
17 signal;

18 the standby host group configured to selectively send a  
19 heartbeat signal to the production host group by use of at least  
20 one of the network and the second remote link.

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22 17. A method of checking for failure in a cluster computing  
23 system, the method comprising:  
24 generating a heartbeat signal from a production host group;

1       selectively sending the heartbeat signal to the standby  
2 host group from the production host group by use of at least one  
3 of a network and a remote link; and

4       enabling the standby host group to manage operations of the  
5 cluster computing system if an invalid heartbeat signal is  
6 received by the standby host group from the production host  
7 group.

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9 18. The method of claim 17 further comprising:

10       selectively sending a heartbeat signal to the production  
11 host group from the standby host group by use of at least one of  
12 a network and a second remote link.

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14 19. The method of claim 17 further comprising:

15       installing remote mirrors in the cluster computing system,  
16 including:

17       registering a first storage volume to a device address  
18 entry, the first storage volume located in a production site,  
19 and, from the production site, changing a remote mirror that  
20 includes the first storage volume into an enabled mode;

21       sending an activation message from the production site to a  
22 standby site;

1       registering a second storage volume to the device address  
2 entry, the second storage volume located in the standby site;  
3 and

4       from the standby site, changing the remote mirror into an  
5 enabled mode to install a remote mirror formed by the first  
6 storage volume and second storage volume.

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8 20. The method of claim 17 further comprising:  
9       de-installing remote mirrors in the cluster computing  
0 system, including:

1       from a production site, changing a remote mirror into a  
2 disabled mode;

3       sending a de-activation message from the first production  
4 site to a standby site; and

5       from the standby site, changing the remote mirror into a  
6 disabled mode to de-install the remote mirror.

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18 21. The method of claim 17 wherein the selectively sending step  
19 comprises:

20       determining if a network between the production site host  
21 and the standby site host is enabled;

22       if the network is enabled, sending a heartbeat message along  
23 the network from the production site host to the standby site  
24 host;

1       determining if a remote mirror between the production site  
2 host and the standby site host is enabled; and  
3       if the remote mirror is enabled, sending a heartbeat message  
4 along the remote mirror from the production site host to the  
5 standby site host.

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7 22. The method of claim 17 further comprising:  
8       receiving a heartbeat message from the production site host  
9 to the standby site host in the cluster computing system,  
10 including:  
11       determining if a network between the production site host  
12 and the standby site host is enabled;  
13       if the network is enabled, checking for a heartbeat message  
14 along the network from the production site host to the standby  
15 site host;  
16       determining if a remote mirror between the production site  
17 host and the standby site host is enabled;  
18       if the remote mirror is enabled, checking for a heartbeat  
19 message along the remote mirror from the production site host to  
20 the standby site host; and  
21       if an invalid heartbeat is received along the network and  
22 along the remote mirror, enabling the standby host to manage  
23 operations of the cluster computing system.

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1       23. A method of setting a heartbeat checking procedure between  
2       a primary group and a secondary group in a cluster computing  
3       system, the method comprising:

4                 providing a request command that determines the heartbeat  
5        checking procedure;

6                 responsive to the request command, enabling a first  
7        heartbeat check module in the primary group to activate or de-  
8        activate a network between the primary group and the secondary  
9       group;

10                responsive to the request command, enabling the first  
11      heartbeat check module to activate or de-activate a remote  
12      mirror between the primary group and the secondary group;

13                permitting the first heartbeat check module to send the  
14      request command to a second heartbeat check module in the  
15      secondary group;

16                responsive to the request command, enabling the second  
17      heartbeat check module to activate or de-activate the network  
18      between the primary group and the secondary group;

19                responsive to the request command, enabling the second  
20      heartbeat check module to activate or de-activate the remote  
21      mirror between the primary group and the secondary group;

22                if the second heartbeat check module has activated the  
23      network, then checking for a heartbeat signal along the network;  
24      and

1       if the second heartbeat check module has activated the  
2 remote mirror, then checking for a heartbeat signal along the  
3 remote mirror.

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5 24. A method of failure notification in a cluster computing  
6 system, the method comprising:

7       selectively activating a network between a primary group  
8 and a secondary group;

9       selectively activating a remote mirror between the primary  
10 group and the secondary group;

11       checking for a failure occurrence in the primary group;

12       if the network is activated, then sending a failure

13 notification message from the primary group to the secondary  
14 group along the network;

15       if the remote mirror is activated, then sending a failure

16 notification message from the primary group to the secondary  
17 group along the remote mirror; and

18       based upon the failure notification message, displaying in  
19 the secondary group an indication of the failure occurrence.

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